United States Patent [19]

Strashok

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[54] **FLARE WINDSHIELD**

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[52] **U.S. Cl.** **431/202,** 431/278, 431/351

[51] **Int. Cl.** **F23d**

[58] **Field of Search**......................431/350, 351, 352, 431/353, 151, 5, 278, 202; 126/214 D; 23/3 C, 277 C

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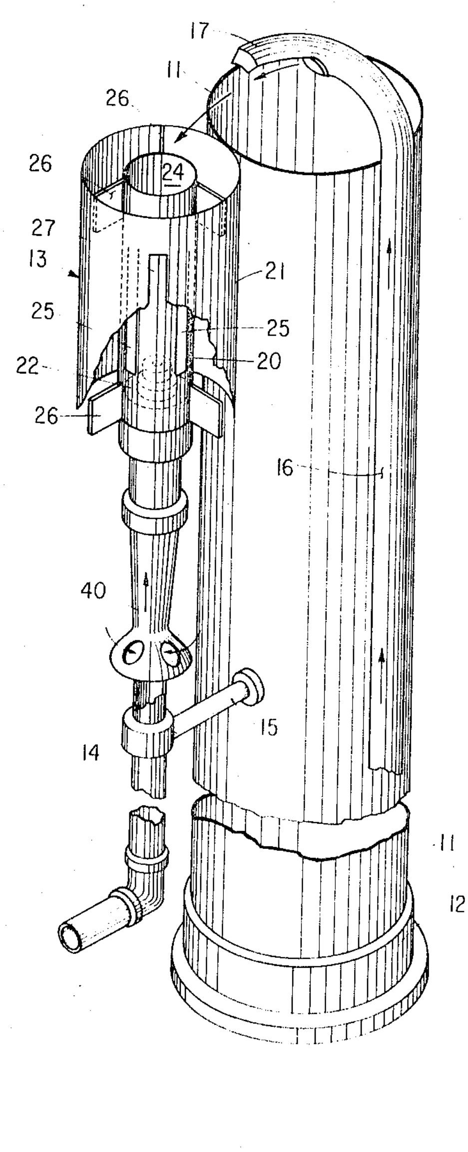
[57] **ABSTRACT**

A windshield for a gaseous fuel flare used for igniting combustible gases flowing from a flare stack makes use of two essentially concentric, slotted, thin-wall cylinders surrounding the flare, with the slots staggered so impedance to high velocity air flow is high. As a result the flare is furnished adequate secondary air, but essentially will not be blown out by wind.

7 Claims, 4 Drawing Figures



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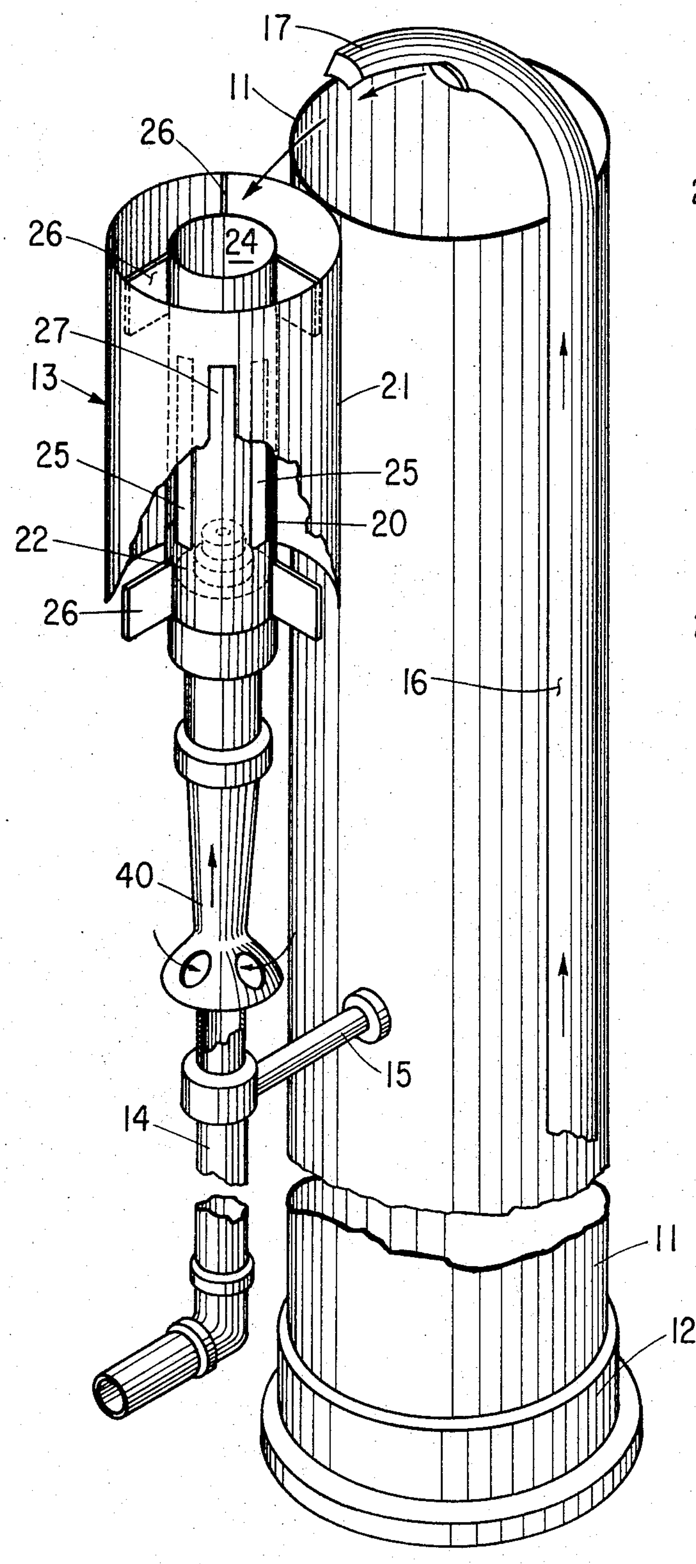

FIG. 1

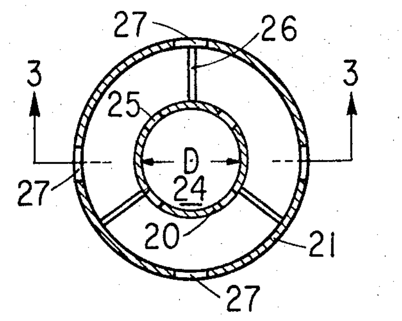

FIG. 4

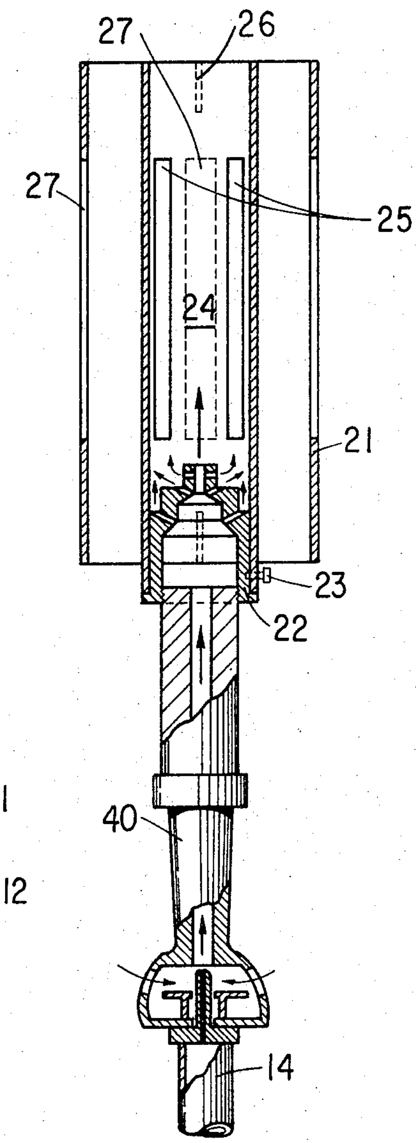

FIG. 3

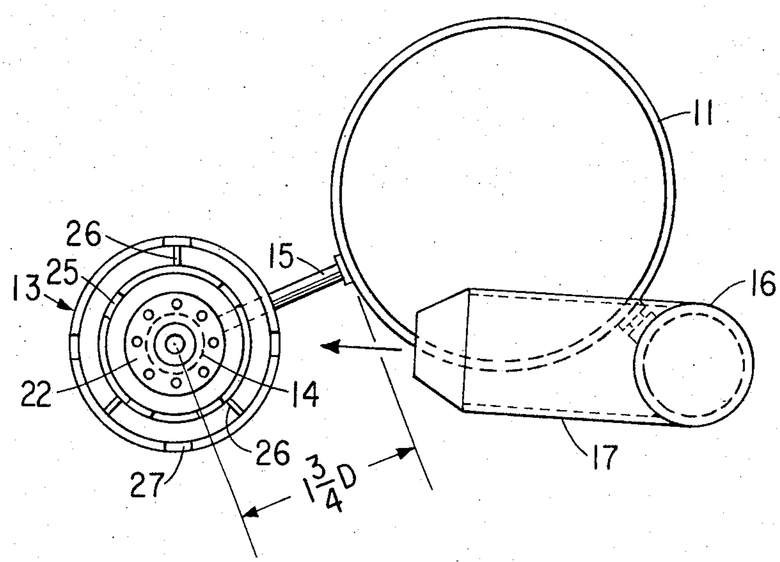

FIG. 2

FLARE WINDSHIELD

BACKGROUND OF THE INVENTION

Field of the Invention

In many fields of chemical and petroleum engineering there is a need for venting to the atmosphere a stream of combustible gas, or a stream containing poisonous gas with which a combustible gas has been mixed, for disposal to the atmosphere. Such a stream is conducted to a stack and a pilot flame or flare is provided at the top of the stack so that the flared gas stream is ignited and burns to harmless constituents. The main stream of gas to the flare stack may vary in flow rate from time to time and consequently it is ordinarily essential to maintain the flare or pilot flame at all times at the top of the stack, so that if the main stream combustion temporarily ceases, reignition can take place. Ordinarily the flare stack itself is simply an essentially vertical pipe with the top sufficiently elevated above ground level so that noxious products of combustion will be adequately diluted in the atmosphere before such components reach ground level. Requirements in recent years have become more stringent and this trend will probably continue. Accordingly, it is exceedingly important that the pilot flame or flare which is located essentially at the top of the main flare stack will continue to burn under all atmospheric conditions, including high winds, gusty winds, storms, low temperatures, etc.

It was found out some years ago that it was desirable when employing gaseous fuel in the flare to pre-mix with this fuel a certain amount of air, called primary air. To a degree, this improved the efficiency of the operation of the flare. Later, various types of shields were placed about the flare itself, permitting in one manner or another additional air (called secondary air) to reach the combustion region at the flare. It was found that a mixture of approximately 30 percent to 40 percent primary air and the balance secondary air gave somewhat increased stability to the flare flame, as did the various forms of windshields. None of these windshields, however, provided adequate flame stability, that is, kept the flare essentially ever-burning. This became increasingly aggravating as the height of flare stacks increased, rendering the remote ignition of such flares ("re-lighting the pilot light") more difficult. Generally, these windshields have been made either as hollow cylinders surrounding the flare, they have end openings for secondary air, and also may be provided with a few small holes in the cylindrical surface. Such arrangements work well in relatively stationary air, but if the wind velocity significantly exceeds 4 ft/second, I have found that this high speed secondary air passing by the flare with a relatively high vertical component tends to blow out the pilot flame. Put another way, the use of such a windshield around the flare does increase flame stability somewhat, but still leaves it inadequate particularly in the modern case of relatively high flare stacks where ignition difficulties are a major aggravation.

Relatively little has been published on this subject. Pilot lights for flare stacks in refineries are usually provided with no windshields at all, or at most, the hollow cylinder-type of sheet iron windshield with no or very low area perforations in the side. I have been unable to find that one can purchase a pilot burner or flare with

an adequate windshield. Neither are such items advertised in the Composite Catalog of Oil Field Equipment & Services, published every two years by the Gulf Printing Company, Houston, Texas. It is to be understood that the conditions under which such burners operate are quite different from the steady-state conditions from which gaseous fuel burners are employed in boilers and the like, the furnaces of which are usually so completely shielded that variation in speed of primary or secondary air is very minor at most. A check of eleven years of the Engineering Index also revealed essentially no information of relevance.

With this dearth of available information, I found it necessary to design windshields for flares to be used with flare stacks of the order of 75 feet in height or more and in an area (near the Canadian Rocky Mountains) where high, variable wind velocity and direction is quite usual, as are temperature extremes. The windshield was designed to furnish and has demonstrated, a proper quantity of secondary air to avoid both the "blow torch effect" caused by too little secondary air and the "wind blowout effect" of too much secondary air. The acoustic impedance of the path between the region outside the windshield and the combustion region at the pilot flame itself was designed sufficiently high so that in practice there was only minor, unimportant variation in speed of the secondary air past the burner tip, resulting in extreme stability of the flame. The windshield assembly was constructed at very little cost compared to comparable commercially available assemblies. The flame burned with complete combustion, thus being most effective as efficient use of fuel gas and minimal pollution aspects. The stability of the ultimate design is illustrated by the following comparison: Thirty-one 75-foot stacks had been equipped with low pressure gaseous fuel cylindrical flares of a standard design in the East Crossfield gas field of Alberta, Canada. It was found that winds of up to 50 miles/hour, and frequently of gusty conditions, were experienced at this set of flare pipes. Under both the initial design of flare, and the three additional designs of commercially available flares which were employed for a considerable period of time, on the average very poor results were experienced with flame stability, and 35 percent of the pilots were out each day. Since a constituent of the gas in the flare stacks was hydrogen sulfide, such operation of the flares was considered highly unsatisfactory, but until my windshield-protected flare was employed, the above figures were typical. When the design was changed to windshield-protected flares as set out in this specification, the stability problem practically disappeared and burners operated with great reliability. For over one year, in this set of 31 high flare stacks there has been essentially no blowing out of a pilot flame.

The weather conditions encountered during this time include sleet storms, several snows including a six-inch fall, and winds of over 50 miles per hour speed, sufficient to blow down one flare stack. This had been connected to a well which had been suspended, so the flare was not burning. Even this speed of wind did not blow out any of the other flares.

SUMMARY OF THE INVENTION

The major improvement in the gaseous fuel, cylindrical flare consists of furnishing this flare with a windshield made up of two essentially coaxial, thin-walled, hollow cylinders, the inner fitting the flare itself so that no secondary air reaches the pilot flame from the base of the burner. The secondary air reaches the pilot flame through a plurality of axial slots placed at least approximately uniformly around the cylindrical surface of the shield intermediate top and bottom of this shield. These slots are axially long compared to their breadth, and designed so that at an air flow rate of around 4 ft/second the area of all slots is sufficient to apply all of the secondary air required. This secondary air requirement is from about 60 percent to about 70 percent of the total air needed for combustion of the gaseous fuel flow through the burner. The primary air, therefore, constitutes of the order of 30 to 40 percent of the total air. Primary air is mixed with the gaseous fuel in the fuel line leading to the flare or burner tip, this mixture preferably occurring over a distance of the order of around one to 1-½ feet. Put another way, the minimum mixing distance between primary air injection point in the fuel line and the burner tip should be around 20 diameters of the fuel line. This dimension is not particularly critical.

The inner windshield slotted cylinder is axially surrounded by an outer slotted thin-walled hollow cylinder. Preferably the slots are the same shape, number, and area as those in the inner cylinder, but the two cylinders are assembled into the windshield by fixing the larger to the smaller such that the slots of the two are midway between each other. This makes for a high impedance flow path and very markedly decreases the likelihood that high velocity winds, either steady or in gusts, will blow out the flame.

A preferred means for remote actuated ignition of this flare in case it does go out is provided; however, this igniter seems to be necessary only the first time one lights the flare after the fuel gas has been turned on.

BRIEF DESCRIPTION OF THE DRAWINGS

The attached drawings form a part of this invention and are to be read in conjunction therewith. In these drawings:

FIG. 1 shows an elevation partly in cross section of a main flare stack furnished with a windshield-protected flare or pilot burner made in accordance with this invention.

FIG. 2 shows a plan of the upper part of this assembly.

FIG. 3 shows a cross section of the windshield and pilot burner.

FIG. 4 shows a section across the windshield shown in FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the main flare stack **11** mounted on a base **12** is provided at the upper end by a pilot (including windshield) indicated generally at **13**. The top of this pilot **13** (that is, the top of the windshield), is opposite the top of stack **11** and mounted a short distance away from but affixed to the flare stack **11**. For example, the fuel line **14** to the burner and windshield assembly **13** may be affixed through a welded fixture **15** which permits the pilot to slide vertically relative to the flare stack. This fixture is placed on the fuel line, below the air mixer **40** to avoid strain and subsequent breakage of the air mixer caused by differential expansion of the fuel line and flare stack. Preferably the axis of the windshield assembly is located about 1-¾ D from the outer edge of the flare stack **11**, as shown in FIG. 2, D being the inner diameter of the inner cylinder, or the diameter of the flare itself, that is, of the pilot burner. Spacing of the order of 1-½ D to 2 D is quite acceptable; spacings greater than this are apt to cause occasional difficulty in ignition of combustible gas in the main flare stack **11**.

A number of remote actuated igniters are on the market, usually of spark plug type, actuated by high tension coil. One of these may be mounted in or near windshield assembly **13**; however, I have found that one particularly advantageous arrangement for a remote actuated igniter fixed to the flare stack is to provide a pipe **16** which is attached to the main flare stack **11** and provided at its upper end with a bent portion **17** such that the top end of this pipe is essentially horizontal and oriented in the direction of the axis of the windshield assembly **13**. The lower end of pipe **16** terminates a convenient distance from the ground, such as five feet. After the fuel gas is turned on in fuel line **14**, the flare (pilot burner) is ignited by firing up the pipe **16** a Very pistol, aviation signal flare, or the like. The burning material passes up through pipe **16**, is deflected by the bent portion **17**, and emerges over the windshield assembly **13** to light the pilot. This has proved to be very effective. Incidentally, the most forward part of the bent portion **17** is preferably cut away diagonally with a lip to direct the burning material into the pilot assembly, about as illustrated in FIGS. **1** and **2**.

The windshield and flare assembly is better shown in cross section in FIG. 3. The windshield itself in section along plane **4—4** is shown in FIG. **4**. The windshield consists of two essentially coaxial thin-walled cylinders **20** and **21**. These are either made of thin-walled pipe or of sheet metal, preferably with a wall thickness not exceeding about D/8, where D is the outer diameter of the cylindrical burner **22** mounted above the mixing zone length of pipe **40**. The inner cylinder is provided at the bottom with a clamping means, such as machine screw **23**, for fastening the windshield assembly to the lower part of burner **22**.

Incidentally, the burner **22** may be of any preferable shape. I have used several without finding that any one shape is essential.

The inner cylinder **20** extends above the top of the burner **22** about 2 to 4 times D, being approximately 3 D in the version shown in FIG. 3.

There are a plurality of axial slots cut in the walls of the inner cylinder and spaced about uniformly about the circumference of it, as shown in FIGS. 3 and 4. Each of the slots **25** has an axial length large compared to the circumferential dimension or breadth, which is preferably in the range of approximately D/5 to D/3. The bottom of the slot is about at the top of burner **22**. The area of these slots, and their placement relative to the matching slots in the outer cylinder **21**, are of definite importance. It was mentioned earlier that it was desirable to use approximately 30 to 40 percent of the total combustion air in the form of primary air which is mixed with a gaseous fuel in the mixer **40** at a minimum distance of about **20** internal diameters of pipe **14** from the burner **22**. For example, in a typical successful flare made in accordance with my invention, the gas supply was approximately 4.7 thousand cubic feet/day and essentially consisted of methane. Accordingly, the total air required for combustion, which is approximately 10 times the volume of the gaseous fuel in this case, amounts to 47,000 cubic feet/day of which the primary air should be around 14,000 to around 19,000 cubic feet/day. This is aspirated into the mixer **40** and mixed with the fuel gas in the mixing zone as the two flow to the burner. The secondary air required is in this case 47,000 cubic feet/day less that required for primary air, or in the range of about 33,000 to about 28,000 cubic feet/day.

I have found that a reasonable secondary air velocity for slot area design is around 4 feet/second. Thus, for a secondary air flow of 30,000 cubic feet/day or 0.35 cubic feet/second, the total slot area would be 0.35 4, or 0.0875 square feet, or **12**.6 square inches. If this is all related back to the rate of flow of the gaseous fuel measured in cubic feet/second and the number corresponding to this flow is designated Q, it is found that the total slot area in square feet lies approximately in the range of 1.5 Q to 1.75 Q.

The heat generated by the flare is sufficient in calm days to produce enough draft to cause secondary air flow through the four axial slots **25** enough to keep a steady burner flame. However, when high or gusty winds are encountered, the need for the second, outer, thin-walled cylinder **21** becomes apparent. I have found it is desirable to make the diameter of the outer cylinder about in the range of 1.5 to 2.5 times D and the wall thickness of the outer cylinder again not exceeding about D/8. I provide this outer windshield or cylinder **21** preferably with the same number of slots of the same shape and size as those in the inner shield and located so that the slot center of inner and outer cylinders is about on the same level. However, the two cylinders are affixed together by radial ribs **26** above and below the slots in such a manner that each of the slots **25** in the inner cylinder **20** is at least roughly arcuately midway between the slots **27** in the outer cylinder **21**. This is shown in FIG. **4**. Such arrangement insures that there is a considerable baffling action between the inner and outer cylinders **20** and **21** so that the average velocity of the secondary air through the slots **25** in practice does not increase markedly above the design figure of 4 feet/second, even in strong or gusty winds.

The closer the inner diameter of outer cylinder **21** approaches the outer diameter of inner cylinder **20**, the greater is this baffling action. However, there is a desirable minimum radial spacing between these dimensions of the two cylinders. If the outer cylinder is too close to the diameter of the inner cylinder, there is very little flow of secondary air through the slots **25** and the flare is starved. To avoid this I have found it is desirable to make the diameter of the outer cylinder about 1.5 to 2.5 times D. Put another way, the spacing between centers of adjacent axial slots **25** and **27** should be of the order of about 0.6 to 0.7 D. As mentioned above, the bottoms of the slots should be approximately axially coincident with the top of the burner **22**.

It is possible to vary from the design figures given, and, in fact, most dimensions have been expressed in a range. However, extreme deviation from any of these dimensions will minimize the effective design, which essentially produces an ever-burning flare as long as the fuel gas continues to flow into fuel line **14**.

Reference to the cross section of FIG. **4** gives several design features which it is believed have aided the singularly good field performance of this windshield. In the first place, it is noted that secondary air entering the inner cylinder **20** has necessarily followed a relatively long path from the outside atmosphere: through a port **27** then around a sinuous path in the annulus between cylinder **20** and **21**, then through a port **25**. Due to the length of path, there is a very appreciable acoustic inductance in the path from the outer atmosphere to the combustion zone. At the same time this path to any port is flanked by acoustic capacitance from the air pockets adjacent the path of direct flow, as, for example, the annular space between cylinders **20** and **21**. This combination of series inductance and shunt capacitance produces an acoustic low-pass filter which tends to decrease or filter out the effects of varying air pressure due to wind gusts occurring outside of the ports **27**, and produce much more steady-state conditions within cylinder **20**. This same effect also occurs with respect to flow paths from either the top or the bottom of the annular space between cylinders through the ports **25** into zone **24**.

As far as steady state effects are concerned, it appears that the use of slots which are long in the axial direction and short in the circumferential direction has made the design rather impervious and in fact considerably less than linearly responsive to the effect of high speed wind outside cylinder **21**. This of course implies that the resistance to flow goes up rapidly as the wind speed increases. The combination of the use of these narrow, axially long slots with the "staggering" of the slots in the inner and outer cylinders has done a very effective job of minimizing blowing out the flare in high wind velocities. Finally, the essentially circumferential symmetry of the design means that it is no more susceptible to wind from one compass direction than from another--a fact also borne out in observation of the field tests.

I claim:

1. A windshield for a gaseous fuel cylindrical pilot affixed near the top of a flare stack, said pilot containing a burner located below the top of said stack and a source of fuel for said burner so that an igniting flame may be maintained at said burner, said windshield comprising two essentially coaxial thin-walled cylinders, the diameter of the outer exceeding the diameter D of the inner cylinder, the diameter D being essentially the diameter of said burner of said pilot, the height of each cylinder above the top of the burner of said pilot being in the range of about two to four times D and terminating at about the same axial distance from the top of said burner; said cylinders being radially connected together near the top and near the bottom of said cylinders and axially affixed to and mounted on said burner, each of said cylinders containing a plurality of axial slots placed about uniformly about the circumference thereof, the axial length of each of said slots being large compared to its circumferential dimension, said circumferential dimension of a slot being approximately in the range of D/5 to D/3, said slots being approximately uniform in area and the total area of said slots in square feet lying approximately in the range of (1.5sec./ft.)Q to (1.75sec./ft.)Q, where Q is the rate of flow of the gaseous fuel for said pilot measured in cubic feet per second; and

the slots in the outer cylinder being substantially of the same number, shape, and size, as those of the inner shield, but being located arcuately approximately midway between the slots of said inner cylinder.

2. Apparatus in accordance with Claim 1 in which the wall thickness of either cylinder does not exceed about D/8, the spacing between centers of adjacent slots in said inner and outer cylinders is approximately 0.7 D, and the bottoms of the slots are approximately axially coincident with the top of said pilot.

3. Apparatus in accordance with claim 2 in which the diameter of said outer cylinder is about in the range of 1.5 to 2.5 times D.

4. Apparatus in accordance with claim 3, said inner cylinder being extended below the base of said outer cylinder to include clamping means thereon for attaching said windshield to said pilot.

5. Apparatus in accordance with claim 4, including means for mounting said windshield and said flare parallel and fixed to said flare stack at a spacing of about 7D/4 from windshield axis to outer edge of said flare stack and with the windshield top at least approximately in the plane of the top of said flare stack.

6. Apparatus in accordance with claim 5, including a remotely actuated igniter for said flare fixed to said flare stack adjacent the top of said windshield.

7. Apparatus in accordance with claim 4, including a cylindrical burner of diameter D containing at its lower end a means for mixing gaseous fuel with air prior to combustion in said burner, said windshield and said burner being substantially axially aligned, and said windshield being mounted about said burner.

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